

Original Research Template: (2250 character limit, ~375 words)

MINIATURE BIOSENSOR WITH HEALTH RISK ASSESSMENT FEEDBACK

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INTRODUCTION: Heart rate (HR) monitoring is a medical requirement during exercise on the International Space Station (ISS), fitness tests, and extravehicular activity (EVA); however, NASA does not currently have the technology to consistently and accurately monitor HR and other physiological data during these activities. Performance of currently available HR monitor technologies is dependent on uninterrupted contact with the torso and are prone to data drop-out and motion artifact. Here, we seek an alternative to the chest strap and electrode based sensors currently in use on ISS today. This project aims to develop a high performance, robust earbud based biosensor with focused efforts on improved HR data quality during exercise or EVA. A health risk assessment algorithm will further advance the goals of autonomous crew health care for exploration missions.

METHODS: All protocols were approved by the Institutional Review Board at NASA Johnson Space Center. Subjects were asked to complete a treadmill (N=5) and/or cycle (N=5) session at a range of intensities. HR data were compared to a 3-lead ECG beat-to-beat analysis. Data was considered comparable if ECG and biosensor data were within ± 5 bpm. Subjectively, the ear bud HR sensor performed better when HR was < 150 bpm. Data were analyzed both across the full session and for periods of activity where HR was < 150 bpm. Subjects (N=4) also completed a long-term wear session and were asked to record their temperature with a commercial ear probe thermometer at hourly intervals, which were compared to temperature data collected by the biosensor.

RESULTS: During cycle tests, 96% of the ECG and biosensor data were within the threshold. During treadmill tests, 55% of the data were within ± 5 bpm. with higher levels of accuracy at heart rates below 150 bpm. Temperature data collected with the biosensor during work day were on average $< 1^\circ\text{F}$ different from that collected with the ear probe thermometer.

DISCUSSION: The biosensor performed better during cycling than during treadmill running, and generally during lower intensity exercise. The biosensor provided high quality temperature data during all test scenarios. Motion artifact and ear bud fit are likely the cause of the decreased HR data quality > 150 bpm. An industrial design for a new biosensor form factor was completed and a health risk algorithm was developed to provide the user with real-time biometric feedback. Partnerships with the military have been established to evaluate the biosensor for use during casualty care in the field.